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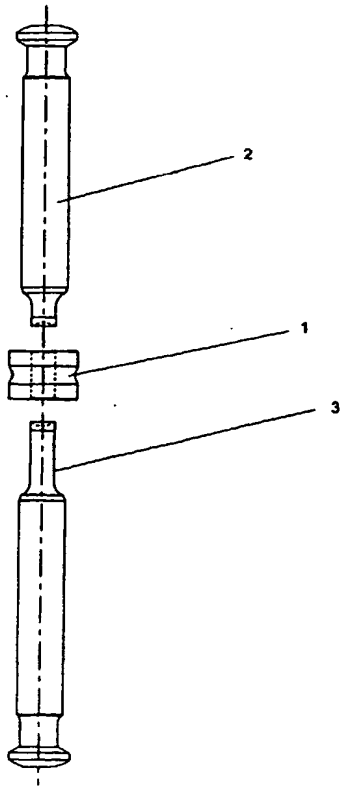
(54) Abstract Title
Tabletting dies made from sintered ferrous powder

(57) A die 1 for making tablets is made by compacting a ferrous powder to form a near net shape and then sintering the compact. The ferrous powder may be mixed with additives such as lubricants and/or machining aids prior to compaction. Compaction may be perfomed in a high pressure hydraulic press. Sintering may be performed in a furnace having a controlled atmosphere, e.g. nitrogen or nitrogen and hydrogen. The die 1 may be heat-treated and tempered following sintering. The ferrous powder may be steel, e.g. Brico (Rtm) 36xx powder metallurgy tool steel which comprises (by weight): 0.8-3.0 % carbon, 3.0-6.0 % chromium, 0.5-3.0 % vanadium, 6.0-11.0 % molybdenum, 5.0-10.0 % cobalt, 0.1-3.0 % tungsten and 0.3-2.0 % silicon. Dies 1 made in this manner may be used to make pharmaceutical pills, dishwasher tablets and certain forms of confectionary.

Figure 1



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(58) Field of Search
UK CL (Edition T) **B5A , C7D DB500**
INT CL[7] **A23G 3/12 3/18 , A23P 1/10 , A61J 3/06 3/10 , B22F 5/00 5/10 , B29C 33/38 , B30B 11/02 11/04 11/08 11/10 11/12 11/14**
Online: PAJ, WPI

Figure 1

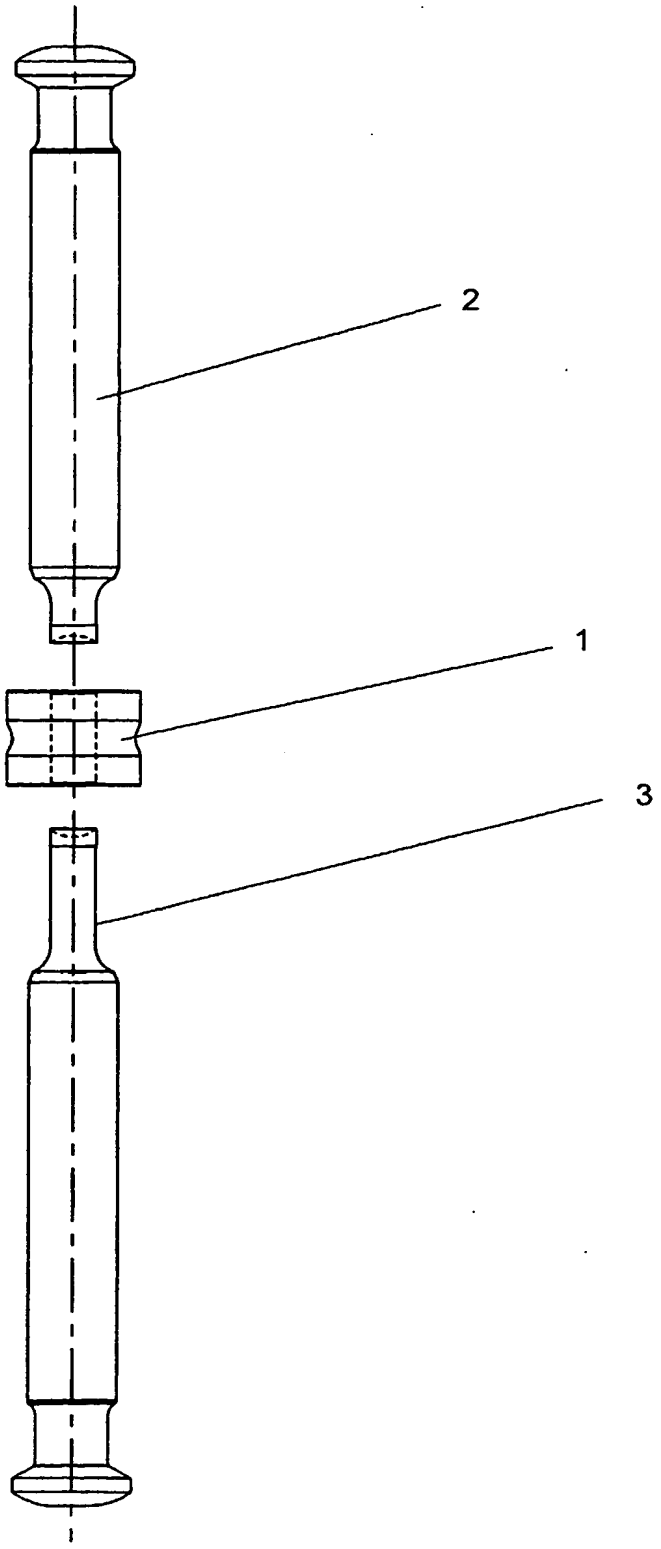


Figure 2

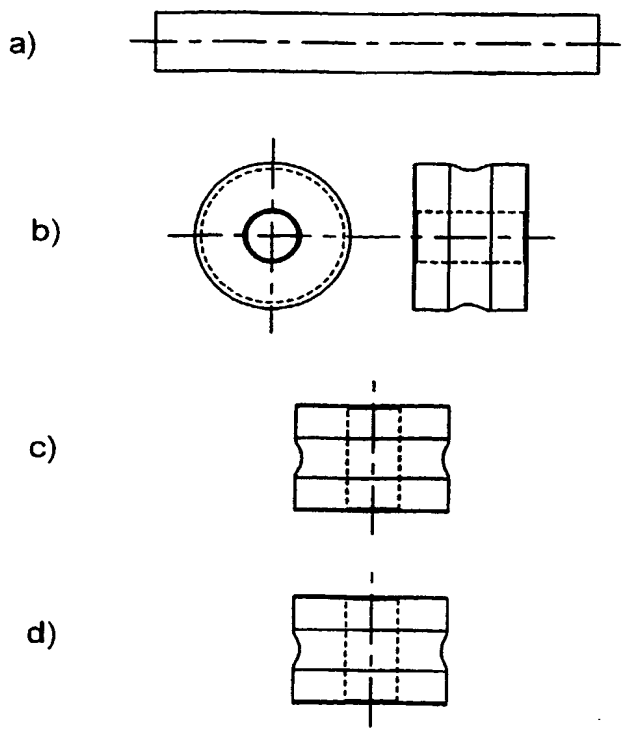
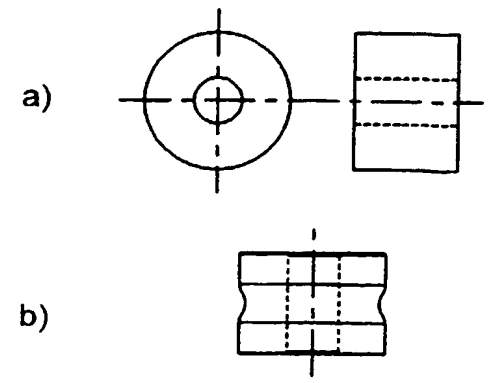


Figure 3



Title – Improvements in Tabletting Dies

This invention relates to improvements in tabletting dies, and in particular to an improved method for the manufacture of such dies, and to dies produced in accordance with that method.

Many products are prepared in the form of tablets. Examples are pharmaceutical pills and certain forms of confectionery, as well as other products such as dishwasher tablets. Such products are manufactured by compression of powders, normally in an automated process using a tabletting machine.

A tabletting machine normally comprises numerous sets of tablet tooling, a typical example of which is illustrated in Figure 1. This comprises a die 1 and upper and lower punches 2,3. The die 1 has an axial cavity, commonly but not necessarily circular in cross-section, within which the tips of the punches 2,3 are closely received.

The punches 2,3 are used to apply a compressive force to powder held between them and within the die's axial cavity, the tips of the punches commonly being concave so as to cooperate with the wall of the cavity to define the shape and dimensions of the tablet.

Tabletting dies are subjected in use to considerable wear and abrasion, as a result of which they have a finite lifetime, at the end of which they must be replaced. Since a tabletting machine may contain a considerable number, typically forty or so, tabletting sets, this is expensive. Tabletting sets may also need to be replaced if products of different shape and dimension are to be produced, or to prevent cross-contamination between products.

The present invention relates to the tablet die. Such dies are conventionally manufactured from steel bar stock by a multi-stage process involving soft

machining to near-nett shape, followed by heat treatment and tempering, and finally hard machining and polishing.

This current manufacturing process is complex and costly, beginning with expensive tool steel bar stock and involving multiple machining stages and intermediate heat treatment. There is considerable manufacturing time and work-in-progress leading to an expensive product. Material utilisation is low, due to the need to remove large amounts of material for the die cavity and in rectification of external surfaces.

There has now been devised an improved method for the manufacture of tabletting dies, and tabletting dies manufactured by that method, which overcome or substantially mitigate the above-mentioned or other disadvantages associated with the prior art.

According to a first aspect of the invention, a process for the manufacture of a tabletting die comprises the steps of

a) compacting a ferrous powder to form a compact of near-nett shape; and

b) sintering the compact.

The process according to the invention is an example of a powder metallurgy process. It is advantageous primarily in that it may significantly reduce material and manufacturing costs and improve material properties to prolong tablet die life. Most commonly, for the tablet die manufacturer the new process would begin with the delivery of tool steel blanks, pre-formed to near-nett shape with a pre-formed bore hole, pre-heat treated and pre-tempered. This removes the need for the current initial manufacturing stages of soft machining and heat treatment. In addition, there are advantages of improved material supply.

The process according to the invention may also provide benefits of improved material composition, homogeneity and mechanical properties. Powder metallurgy products can achieve very high levels of material homogeneity and

consistency, providing improved isotropic mechanical characteristics. Transient liquid phase sintering provides the mechanism by which full densification is achieved. This is to be compared with traditional techniques in which cast ingots are rolled and drawn, leading to segregation within the melt and allowing foreign matter to form inclusion defects during casting or rolling. Unlike ingot products, powder metallurgy materials can include machining-aid and solid lubricant particles to aid machining.

The process according to the invention will typically be carried out by a specialist supplier and not by the tablet die manufacturer. Processing begins with the production of a suitable powder and mixing it with necessary additives. The powder is squeezed into shape under high pressure on a press, preferably a hydraulic press. The resulting "green" compact is heated in a high-temperature furnace to bond the particles together by the phenomenon known as sintering, ie bonding the particles together by a process of metallurgical fusion without melting. The furnace is preferably a controlled atmosphere furnace. The compact is preferably fed slowly through the furnace.

By a compact of "near-nett shape" is meant a compact having a shape and dimensions substantially identical to those of the desired tablet die, ie shape and dimensions sufficiently close to those of the end-product that the final dimensions can be readily achieved by hard machining operations.

For dies with a round bore hole or cavity, ie those for the manufacture of round tablets, the bore hole may be pressed and sintered close to the required final dimensions ready for finish hard turning and honing. For dies with a differently shaped bore hole, the blanks may be supplied with a small pilot hole ready for formation of the shaped cavity, eg by wire spark erosion. Alternatively, bore holes or the like may be entirely formed in a subsequent machining operation.

Following sintering, and prior to final hard machining, it may be necessary or desirable to perform heat treatment and tempering. This alters the crystalline

structure of the steel to provide the necessary properties of wear resistance and toughness.

The ferrous powder used in the present invention will generally be a steel. Suitable steels will be apparent to those skilled in the art or the suitability of any particular steel may readily be ascertained. One suitable steel is that referred to as Brico(tm) 36xx (Federal-Mogul Sintered Products Limited, Coventry, United Kingdom) which is described in British Patent Application GB 2301376A.

The ferrous powder may be mixed with finely divided additives such as lubricants and machinability aids which will then be dispersed in the compact and which may then improve the machining characteristics of the finished product. The properties of the finished product will also be altered by heat treatment and tempering. For example, the sintered blank may be hardened to high hardness and then tempered back to achieve reduced brittleness and improved machinability.

The crystal structure of the tablet die produced in accordance with the invention is different to that of a tablet die produced by the prior art method of machining from steel bar stock. This can be verified by metallographic examination.

Thus, according to a second aspect of the invention, there is provided a tabletting die produced by compaction and sintering of a ferrous powder.

The invention will now be described in greater detail, by way of illustration only, with reference to the accompanying drawings, in which

Figure 1 shows a typical tabletting set;

Figure 2 illustrates stages in a conventional manufacturing process for a tabletting die; and

Figure 3 illustrates stages in the process according to the present invention.

Referring to Figure 1, which has already been described, a tabletting set used in a tabletting machine comprises a die 1 and upper and lower punches 2,3. Typically, forty such tabletting sets will be fitted in a carousel on a tabletting machine. The present invention is concerned with the die 1.

The prior art method of manufacturing a die 1 is illustrated in Figure 2. The starting point is steel bar stock (Figure 2(a)). Typically, the steel used is D2 cold work tool steel, a high carbon, high chromium steel with the typical composition by weight shown in Table 1. The steel bar stock is soft machined to near-nett shape (Figure 2(b)), then heat-treated and tempered (represented by Figure 2(c)). Finally, the die is hard machined and polished (Figure 2(d)).

In an embodiment of the present invention, the starting point is Brico 36xx powder metallurgy tool steel, the composition by weight of which is set out in Table 2. Additives such as machining aid and solid lubricant particles may be added to modify the properties of the sintered material.

The powdered steel is compacted by pressing in a suitable mould using a hydraulic press to form a "green" compact. The compact is then passed through a high temperature furnace under an inert atmosphere (typically nitrogen or nitrogen plus hydrogen). The temperature of the furnace will typically be in excess of 1000°C, eg 1100-1300°C. After sintering, the compact is heat-treated and tempered to yield a steel blank of near-nett shape and with a pre-formed bore hole (Figure 3(a)). It is in this condition that the blank would normally be delivered to the tablet die manufacturer who would subject the blank to finish hard turning and honing to yield the final product (Figure 3(b)).

Table 1

D2 Cold Work Tool Steel (BS 4659:BD2)

Typical Analysis	
Carbon	1.5%
Chromium	12.0%
Vanadium	0.9%
Molybdenum	0.9%
Iron	remainder

Table 2

Brico (rtm) 36xx Powder Metallurgy Tool Steel

	Possible Range	Typical Analysis
Carbon	0.8 – 3.0%	1.1%
Chromium	3.0 – 6.0%	3.6%
Vanadium	0.5 – 3.0%	1.2%
Molybdenum	6.0 – 11.0%	9.4%
Cobalt	5.0 – 10.0%	8.1%
Tungsten	0.1 – 3.0%	1.7%
Silicon	0.3 – 2.0%	0.8%
Manganese		0.2%
Others	2.0% max.	
Iron	remainder	remainder

Claims

1. A process for the manufacture of a tabletting die, said process comprising the steps of

a) compacting a ferrous powder to form a compact of near-nett shape; and

b) sintering the compact.

2. A process as claimed in Claim 1, wherein the ferrous powder is mixed with additives prior to compaction.

3. A process as claimed in Claim 2, wherein the additives are finely divided lubricants and/or machinability aids.

4. A process as claimed in any preceding claim, wherein the compaction of the ferrous powder is carried out using a high pressure press.

5. A process as claimed in Claim 4, wherein the press is a hydraulic press.

6. A process as claimed in any preceding claim, wherein the sintering of the compact is carried out using a high-temperature furnace.

7. A process as claimed in Claim 6, wherein the furnace is a controlled atmosphere furnace.

8. A process as claimed in any one of Claims 6 and 7, wherein the compact is fed slowly through the furnace.

9. A process as claimed in any preceding claim, wherein the tabletting die is heat treated and tempered following sintering.

10. A process as claimed in any preceding claim, wherein the ferrous powder is steel powder.

11. A process as claimed in any preceding claim, wherein the ferrous powder comprises 0.8-3.0% Carbon, 3.0-6.0% Chromium, 0.5-3.0% Vanadium, 6.0-11.0% Molybdenum, 5.0-10.0% Cobalt, 0.1-3.0% Tungsten and 0.3-2.0% Silicon by weight.

12. A tabletting die produced by compaction and sintering of a ferrous powder.

13. A tabletting die as claimed in Claim 12, produced by compaction and sintering of steel powder.

14. A tabletting die as claimed in Claim 12, wherein the ferrous powder comprises 0.8-3.0% Carbon, 3.0-6.0% Chromium, 0.5-3.0% Vanadium, 6.0-11.0% Molybdenum, 5.0-10.0% Cobalt, 0.1-3.0% Tungsten and 0.3-2.0% Silicon by weight.

15. A tabletting die as claimed in any one of Claims 12 to 14, produced by compaction and sintering of a mixture of a ferrous powder and one or more additives.

16. A tabletting die as claimed in Claim 15, wherein the additives are finely divided lubricants and/or machinability aids.

17. A process for the manufacture of a tabletting die, substantially as hereinbefore described.

Application No: GB 0124113.2 **Examiner:** Matthew Lawson
Claims searched: 1-17 **Date of search:** 12 April 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): B5A; C7D (DB500)

Int Cl (Ed.7): A23G 3/12, 3/18; A23P 1/10; A61J 3/06, 3/10; B22F 5/00, 5/10; B29C 33/38; B30B 11/02, 11/04, 11/08, 11/10, 11/12, 11/14

Other: Online: PAJ, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
&,E	EP 1147879 A1 ✓	(TAKEDA) - pub. 24.10.2001 - page 2 lines 16-17, page 3 lines 33-36 and the figure.	
X,&	WO 00/44554 A1	(TAKEDA) - see EP 1147879.	1-16
X	WO 95/26421 A1	(FEDERAL) - the whole specification, especially page 4 lines 9-15 & 23-27.	1-16
X	JP 110158571 A ✓	(TAKEDA) - WPI Abstract Accession No. 99-400470/34 the PAJ abstract and figure 1.	1 & 12 at least
X	JP 030272815 A	(NIPPON) - WPI Abstract Accession No. 92-027378/04, the PAJ abstract and figures 1 & 2.	1 & 12 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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